IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

STRUCTURAL PERFORMANCE OF PRE-ENGINEERED INDUSTRIAL WAREHOUSE BUILDING

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Abstract - *This Artical focuses on the modeling and analysis of Pre-Engineered Building (PEB) structures in the Nagpur and Nashik regions using STAAD Pro software. The aim was to gain valuable insights and draw conclusions regarding the performance and suitability of PEB structures in these specific locations. The findings of this thesis have significant practical implications for the construction industry in the Nagpur and Nashik regions. Architects, engineers, and decision-makers can utilize the knowledge gained from this research to effectively and efficiently design and implement PEB structures. Overall, this thesis contributes to the understanding of PEB structures in the context of the Nagpur and Nashik regions. It lays the foundation for further research and development, suggesting future areas of exploration such as advanced analysis techniques, integration with Building Information Modeling (BIM), material innovations, and life cycle assessments. These avenues of research can further enhance the design, construction, and sustainability aspects of PEB structures in these regions.*

Key Words: **Pre-Engineered Building (PEB), structural performance, comparative study, steel structures, finite element analysis, construction process.**

1. INTRODUCTION

Steel structures are widely used in the construction industry due to their strength, durability, and versatility. The use of steel as a structural material offers numerous advantages, making it a popular choice for a wide range of applications, from high-rise buildings and bridges to industrial facilities and stadiums. One of the key advantages of steel structures is their exceptional strength-to-weight ratio. Steel is a highly durable and resilient material that can withstand heavy loads and adverse weather conditions, such as earthquakes and hurricanes, without compromising its structural integrity. This strength allows for the creation of large, open spaces without the need for excessive supporting columns or walls.

1.1 Components of PEB:

Pre-Engineered Buildings (PEB) are designed and manufactured in a factory-controlled environment, where the components are fabricated and assembled. The PEB structure consists of several key components that work together to form a complete building system. The main components of a PEB structure include:

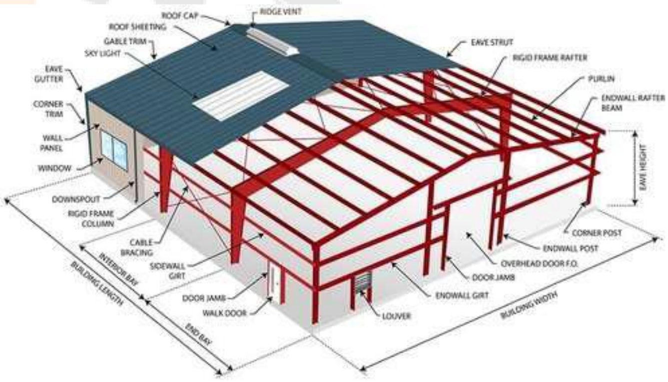

Fig -1: Component of PEB

1.2 AIM

The aim of this thesis is to analyze and model Pre-Engineered Building (PEB) structures in the Nagpur and Nashik regions using STAAD Pro software, and to draw conclusions regarding their performance and suitability for these specific locations.

1.3 OBJECTIVES

- To conduct a comprehensive investigation of PEB structures in the Nagpur and Nashik regions.
- To compare the performance of PEB structures in the Nagpur and Nashik regions in terms of support reactions, moment at support, bending moment, and shear force.

- To quantify the quantity of steel required for PEB structures in the Nagpur and Nashik regions.
- To determine the percentage increase in steel quantity between Nagpur and Nashik.
- To provide valuable insights and conclusions regarding the performance and suitability of PEB structures in the Nagpur and Nashik regions.
- To suggest future scope areas for further research and development in the field of PEB structures in the specified regions, including advanced analysis techniques, integration with Building Information Modeling (BIM), material innovations, and life cycle assessments.

2. LITERATURE

Akash varma[1] (2022): "Analysis and design of Pre-Engineered Building with different parameter". The field of structural engineering and civil engineering has witnessed significant advancements in science and technology. As a result, pre-engineered buildings (PEB) have emerged as a prominent solution in both industrial and residential construction sectors. This literature review aims to explore the concepts and benefits of PEB, focusing on the analysis and design of steel structures using software such as Staadprov8i.

One of the primary objectives of this research is to achieve a thorough understanding of PEB concepts and optimize the structure's weight while ensuring its safety and stability. The analysis involves considering various loads, including dead load, live load, collateral load, wind load, and load combinations. By employing the principles of pre-engineered construction, which emphasizes quality construction systems, the goal is to minimize both cost and time.

The utilization of Staadprov8i software plays a crucial role in the analysis and design process. In one case study, a pre-designed 3D construction model of a warehouse building was developed and compared to a conventional structure constructed with traditional steel. Another example involved designing a 2D flat structure with conical sections, spanning 88m. This particular structure demonstrated the limitations of conventional methods due to its complexity and lack of feasibility. To find the most suitable configuration, different spacing between stalls was considered.

Through meticulous analysis and optimization, an industrial warehouse structure was successfully designed, weighing a mere 253.796 KN. The structure was subjected to rigorous analysis, considering loads and load combinations. The study revealed the maximum shear force (SF) and maximum bending moment (BM) for specific frames, highlighting values such as 173.901 KN (+ve) and 41.017 KN (-ve) for beam 76, and 91.107 KN-m (+ve) and 81.372 KN-m (-ve) for beam 42.

Ultimately, the economic advantages of PEB structures become evident when considering the efficient use of high-grade steel and composite building forms combined with advanced materials. Cost studies conducted on model buildings have demonstrated the economic viability of PEB structures, making them an appealing choice for civil construction projects.

In conclusion, this literature review highlights the growing prominence of pre-engineered buildings in the construction industry. The use of advanced software tools like Staadprov8i enables the analysis and design of efficient and cost-effective structures. PEB structures not only offer substantial cost savings but also align with sustainability goals by utilizing eco-friendly materials. The findings underscore the significance of optimizing PEB structures for weight reduction and achieving safe and stable designs.

Anushri A. Isal[1] et. al. (2022): "Comparative Analysis of PEB Structure with Varying Bay Spacing". Pre-designed buildings, also known as Pre-Engineered Buildings (PEB), utilize a steel frame construction system that optimizes the use of steel by adjusting sections based on bending moment requirements. This concept is widely adopted in industrialized countries, offering a complete building system with pre-designed components that can be combined to meet specific project needs. Compared to conventional steel structures, PEBs offer advantages in terms of shorter construction time and lower costs, making them more economically viable. The focus of this study is to analyze PEB structures using STAAD-PRO software while considering variations in bay spacing.

The study presents a comparative analysis and design of a Pre-Engineered building with a span width of 30m and length of 96m, considering different ridge angles and bay spacings. The analysis involves examining bending moments, beam forces, steel take-off, deflection, and support reactions using STAAD Pro software.

The modeling process involves using STAAD-PRO software to create the building geometry, assign material properties, supports, and loads, analyze the model, and extract and interpret the results. The rectangular-shaped pre-engineered building models are adjusted for different bay spacings, while the span slightly varies.

Based on the analysis, the following conclusions are drawn: For models with 5m spacing, the beam forces exhibit maximum Fx and minimum Fy values. The maximum beam moment, Mx, is observed in models with 5m spacing and a ridge angle of 1 in 10. Models with 6m spacing show higher values of beam forces (Fx) and lower values of Fy. The maximum beam moment, Mx, occurs in models with 6m spacing and a ridge angle of 1 in 10. Models with 7m spacing exhibit higher values of beam forces (Fx) and lower values of Fy. These findings contribute to the understanding of PEB structures and their performance under different bay spacings, aiding in the efficient design and optimization of such buildings.

Anish Goswami[1] et. al. (2018): "Pre-Engineered Building Design of an Industrial warehouse". The concept of Pre-Engineering Buildings (PEB) has revolutionized the construction industry, offering a versatile, efficient, and cost-effective alternative to conventional steel buildings (CSB). This literature review aims to provide an overview of the comparative study and design of PEB and CSB, focusing on their structural performance, cost-effectiveness, and construction efficiency. The study includes the analysis and design of an industrial warehouse structure located in Nagpur, India, using both PEB and CSB concepts.

The present study involves the design of a typical frame for an industrial warehouse structure. A PEB frame with a width of 30 meters, consisting of 8 bays, each 7.5 meters in length, and an eave height of 6 meters, is considered. The structural analysis and design software STAAD Pro is utilized to analyze the designed frame and compare its performance with a CSB frame designed for the same span and considering an economical roof truss configuration.

The critical load for the structure is determined to be wind load.

The comparative analysis of PEB and CSB for industrial construction reveals several advantages of the PEB concept. PEB structures exhibit higher displacement, lower support reactions, reduced self-weight, improved wind load resistance, decreased steel quantity, and minimized material wastage. Additionally, PEB construction allows for smaller foundation sizes, contributing to cost savings. Overall, the PEB concept offers a versatile, lightweight, and cost-effective solution for single-story industrial buildings when compared to conventional steel construction methods.

D. Rakesh[1] et. al. (2016): "Design Analysis of Conventional and Pre-Engineered Building (R.C.C and Steel)". There has been a significant shift in the steel industry, particularly in the construction of industrial structures, where the utilization of Conventional steel buildings and Pre-Engineered buildings has become more prevalent. The concept of Conventional steel buildings and Pre-Engineered buildings represents a new approach to single-storey industrial construction. This methodology stands out due to its quality pre-designing, prefabrication, lightweight nature, and cost-effective construction. The concept emphasizes providing the most suitable sections based on optimal requirements. The entire design process for Conventional steel buildings and Pre-Engineered buildings is carried out in the factory, enabling rapid construction while ensuring aesthetic appeal and quality.

The structural performance of Pre-Engineered buildings is well-established, with adequate code provisions in place to ensure satisfactory behavior under high wind loads. This study focuses on comparing displacement and steel quantity between conventional truss structures and pre-engineered structures. The results demonstrate that pre-engineered structures exhibit less displacement in columns and consume less steel compared to conventional counterparts. Pre-Engineered steel structures offer advantages such as low cost, strength, durability, and design flexibility.

This study also reveals that conventional buildings exhibit higher displacements and lower axial forces compared to pre-engineered buildings. Therefore, it is proposed that Pre-Engineered Building Construction offers cost-effectiveness and reduced construction time compared to Conventional steel building methods.

3. METHODOLOGY

The PEB concept is based on providing sections only where they are required, corresponding to the specific bending moment diagram at each location. This approach allows for the use of non-prismatic rigid frames with slender elements. Tapered I section, created using built-up thin plates, are utilized to achieve this desired configuration. In addition to tapered sections, standard hot-rolled sections, cold-formed sections, and profiled roofing sheets are also employed. This combination of components allows for optimal utilization of the least amount of material, resulting in significant steel savings and cost reduction. The fundamental principle of the PEB concept is to align the frame geometry with the internal stress (bending moment) diagram, effectively optimizing material usage and reducing the overall weight of the structure.

3.1 Model Parameter

This research will study a total of 8 models, comprising 4 models each from Nagpur and Nashik. These models will have different bay spacing of 5m, 6m, 7m, and 8m. By comparing their results, a conclusion will be drawn.

Structural frame for wall studs, bracings, runners, roof truss and purlins etc preferably made of cold rolled steel sections (conforming to IS 801 / IS 811 / ASTM A 653A, ASTM A 653M) with minimum 345 MPa of yield strength.

Table -1: Specifications of PEB Structure for modeling

Location	Nagpur, Nasik
Frame Type	Clear Span, Rigid Frame
Support	Pinned
Building Width (W) (Columns)	40 m
Building Length (L) (Columns)	80 m
Eave Height (H) (Roof)	10 m
Bay Spacing	5m, 6m, 7m & 8m
Roof Slope	1 in 10
Roof Purlin (Continuous)	1.5 m c/c

4. RESULT

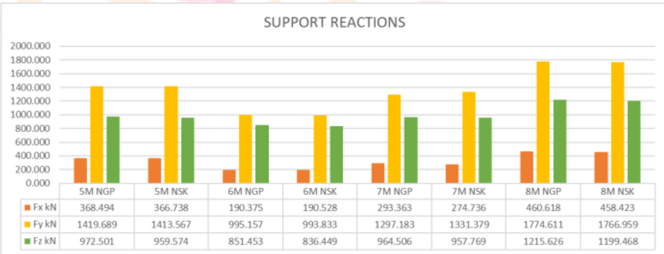

Chart -1: Support Reaction

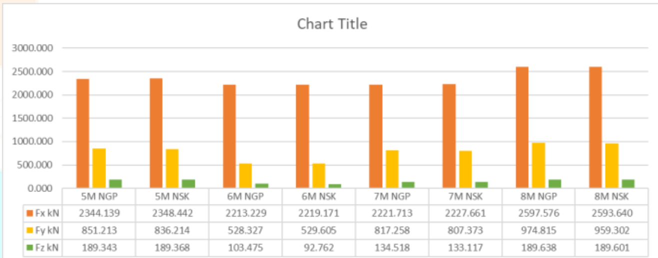

Chart -2: Shear Force

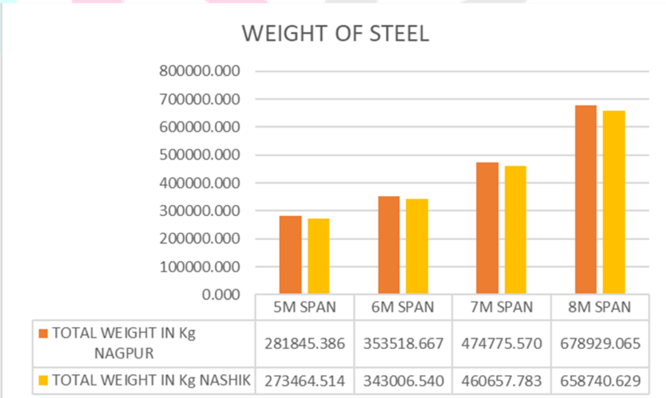

Chart -3: Comparing Steel Quantity for Model 1 and 2

5. CONCLUSION

The thesis focused on the modeling and analysis of Pre-Engineered Building (PEB) structures using STAAD Pro software for the Nagpur and Nashik regions. Through a comprehensive investigation, valuable insights and conclusions have been drawn regarding the performance and suitability of PEB structures in these specific locations.

1. Analysis was done by using STAAD PRO software and successfully, Usage of software minimizes the time required for analysis and design.
2. For model 1 i.e., Nagpur region the Support reactions, moment at support, bending moment and shear force are slightly greater than Nashik i.e., model 2.
3. The amount of steel required increases with the increase in bay span, and due to the higher wind velocity in Nagpur compared to Nashik, the steel quantity is higher in all models for the Nagpur region. The percentage increase in steel quantity from Nagpur to Nashik is approximately 0.456%.
4. The ideal bay spacing found to be 5 to 6 m for both the region.

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